APPENDIX E
ELECTRICAL ENGINEERING DESIGN CRITERIA

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1.0 INTRODUCTION

Control of the design, engineering, procurement, and construction activities on the project will be completed in accordance with various predetermined standard practices and project specific programs/practices. An orderly sequence of events for the implementation of the project is planned consisting of the following major activities:

- Conceptual design
- Licensing and permitting
- Detailed design
- Procurement
- Construction and construction management
- Start-up, testing, and checkouts
- Project completion

The purpose of this appendix is to summarize the codes and standards and standard design criteria and practices that will be used during the project. The general electrical design criteria defined herein form the basis of the design for the electrical components and systems of the project. More specific design information will be developed during detailed design to support equipment and erection specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize the codes, standards, and general criteria that will be used.

Section 2.0 summarizes the applicable codes and standards, and Section 3.0 includes the general design criteria for motors, power and control wiring, protective relaying, classification of hazardous areas, grounding, lighting, freeze protection, lightning protection, raceway and conduit, and cathodic protection.

2.0 DESIGN CODES, STANDARDS, LAWS AND ORDINANCES

The design and specification of all work shall be in accordance with all applicable laws and regulations of the federal government, the State of California, and applicable local codes and ordinances. A listing of the codes and industry standards to be used in design and construction follows:

- The Antifriction Bearing Manufacturers Association (AFEMA)
- American National Standards Institute (ANSI) American Society for Testing and Materials (ASTM)
- Edison Electric Institute (EEI)
- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society (IES)

- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- Occupational Safety and Health Act (OSHA)
- Underwriters' Laboratories (UL)
- National Association of Corrosion Engineers (NACE)

In addition to the general codes and standards listed above, the following specific standards will be utilized:

- Batteries
  - NEMA IB 4-Determination of Amperehour and Watthour Capacity of Lead-Acid Industrial Storage Batteries for Stationary Service
  - IEEE 450-Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries
  - IEEE 484-Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations
- Battery Chargers
  - NEMA AB 1-Molded Case Circuit Breakers
  - NEMA PV 5-Constant-Potential Type Electric Utility (Semiconductor Static Converter) Battery Charger
- Cable, Low Voltage Power, Control and Instrument
  - ASTM B8-Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft
  - ASTM B33-Tinned Soft or Annealed Copper Wire for Electrical Purposes
  - ICEA S-19-81, NEMA WC3-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
  - ICEA S-68-516, NEMA WC-8-Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
  - NFPA 258-Standard Test Method or Measuring the Smoke Generated by Solid Materials
  - NFPA 70-National Electric Code (NEC)

- ANSI/UL 44-Safety Standard for Rubber-Insulated Wires and Cable

- Cable, Medium Voltage Power
  - ICEA 6-Ethylene Propylene Rubber Insulated Shielded Power Cables, Rated 5 through 69 kV
  - ASTM B8-Concentric Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
  - ASTM B33-Tinned Soft or Annealed Copper Wire for Electrical Purposes
  - ICEA S-66-524- Cross Linked-Thermosetting, Polyethylene-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy
  - ICEA S-68-516-Ozone-Resistant Ethylene-Propylene Rubber Insulation for Power Cables Rated 0 to 35,000 Volts
  - ICEA S-19-81, NEMA WC-3-Rubber Insulated Wire and-Cable for the Transmission and Distribution of Electrical Energy
  - NFPA 70-National Electric Code (NEC)

- Cable Tray
  - NEMA VE-1 Cable Tray Systems

- Cathodic Protection Equipment
  - ANSI B1.1-Unified Inch Screw Threads
  - ANSI B2.1-Pipe Threads
  - ASTM A518-Corrosion-Resistant High Silicon Cast Iron
  - ASTM B418-Cast and Wrought Galvanic Zinc Anodes for Use in Saline Electrolytes
  - NEMA AB-1-Molded Case Circuit Breakers
  - NEMA ICS-Industrial Controls and Systems
  - NEMA WC-5, ICEA S-61-402-Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
  - NEMA WC-7, SS-66-524-Cross-Linked-Thermosetting, Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

- Circuit Breakers, High Voltage
  - ANSI/IEEE C37.04-Rating Structure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

- ANSI C37.06-Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI/IEEE C37.09-Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI/IEEE C37.010-Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI C37.11-Requirements for Electrical Control for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis and a Total Current Basis

• Conduit

- UL 6, ANSI C80.1-Rigid Steel Conduit
- UL 797, ANSI C80.3-Electrical Metallic Tubing
- UL 514, ANSI C80.4-All Fittings
- UL 886-Hazardous Area Fittings
- UL 360-Flexible Liquid-Tight Conduit
- NEMA TC6-PVC and ABS Plastic Utilities Duct for Underground Installation
- NEMA TC9-Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation
- UL 651-Electrical Rigid Nonmetallic Conduit
- NEMA TC2, UL 514-Fittings for Electrical Rigid Nonmetallic Conduit

• Distribution Panels

- ANSI C971-Low Voltage Cartridge Fuses, 600 volts or less
- NEMA AB1-Molded Case Circuit Breakers
- NEMA PB1-Panelboards
- UL 50-Electrical Cabinets and Boxes
- UL 67-Panelboards
- NEMA ICS-Industrial Controls and Systems
- NEMA KSI-Enclosed Switches

• Grounding

- ASTM B8-Specifications for Concentric-Lay Stranded Copper Conductors

- NEC-National Electric Code
- NEMA CC-1-Electrical Power Connectors for Substations
- IEEE 80-IEEE Guide for Safety in AC Substation Grounding

• Lighting Fixtures

- NEMA FA1-Outdoor Floodlighting Equipment
- NEMA LE1-Fluorescent Luminaries
- UL 57-Standard for Safety, Electric Lighting Fixtures
- UL 844-Standard for Safety, Electric Lighting Fixtures for Use in Hazardous Locations
- UL 924-Standard for Safety, Emergency Lighting Equipment
- Lightning Arresters
- ANSI/IEEE C62.11-Surge Arresters for AC Power Circuits

• Secondary Unit Substations

- ANSI C37.13-Low-Voltage AC Power Circuit Breakers Used in Enclosures
- ANSI C37.16-Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors
- ANSI/IEEE C37.20-Switchgear Assemblies
- ANSI C37.50-Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures
- ANSI C37.51-Conformance Testing of Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies
- ANSI C57.12.00-General Requirements for Distribution, Power, and Regulation Transformers
- ANSI/IEEE C57.12.01-General Requirements for Dry-Type Distribution and Power Transformer
- ANSI/IEEE C57.12.90-Test Code for Liquid Immersed Distribution, Power, and Regulating Transformers
- ANSI/IEEE C57.12.91-Test Code for Dry-Type Distribution and Power Transformers
- ANSI C57.13-Requirements for Instrument Transformers
- NEMA CC-1-Electrical Power Connectors for Substations
- NEMA TR-1-Transformers, Regulators, and Reactors

- NEMA ICSI-General Standards for Industrial Controls and Systems
- NFPA 70-National Electric Code

- Metal-Clad Switchgear and Nonsegregated Phase Bus
  - ANSI C37.04-Rating Structure for AC High-Voltage Circuit Breakers on a Symmetrical Current Basis
  - ANSI C37.06 Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
  - ANSI C37.20-Switchgear Assemblies Including Metal-Enclosed Bus
  - ANSI C57.13-Requirement for Instrument Transformers
- Motor Control Centers
  - NEMA ST-20-Dry-Type Transformers for NEMA General Purpose Applications
  - NEMA AB-l-Molded Case Circuit Breakers
  - NEMA ICS-l-General Standards for Industrial Controls and Systems
  - NEMA ICS-2-Industrial Control Devices, Controllers, and Assemblies
  - UL 67-Electric Panelboards
  - UL 489-Molded Case Circuit Breakers and Circuit Breaker Enclosures
  - UL 508-Industrial Control Equipment
  - UL 845-Motor Control Centers
  - NFPA 70-National Electric Code
- Motors, Low Voltage
  - NEMA MG1-Motors and Generators
  - AFBMA 9/ANSI B3.15-Antifriction Bearing Manufacturers Association
  - NEMA MG2 AFBMA 11/ANSI B3.16-Safety Standard for Construction and Guide for Selection, Installation and Use of Electrical Motors and Generators
  - NEMA MG13-Frame Assignment for Alternating Current Integral Horsepower Induction Motors
- Motors, Medium Voltage
  - ANSI/IEEE C50.41-Polyphase Induction Motors for Electric Power Generating Stations

- IEEE 112-Test Procedure for Polyphase Induction Motors and Generators
- NEMA MG1-Motors and Generators
- NEMA MG2-Safety Standard for Construction and Guide for Selection, Installation and Use of Electrical Motors and Generators

• Neutral Grounding Resistors

- ANSI C76.1-Requirements and Test Codes for Outdoor Apparatus Bushings
- IEEE 32-Requirements, Terminology, and Test Procedures for Neutral Grounding Devices
- NEMA CC1-Electric Power Connectors

• Relay Panels

- ANSI C37.20-Switchgear Assemblies Including Metal-Enclosed Bus
- ANSI 37.90-Relays and Relay Systems associated with Electric Power Apparatus
- NEMA WC-3, ICEA S-19-81-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

• Transformers, Dry-Type

- ANSI U1-General Requirements for Dry-Type Distribution and Power Transformers
- NEMA ST20-Dry-Type Transformers for General Application
- UL 506-Standard for Safety, Specialty Transformers

Other recognized standards will be utilized as required to serve as design, fabrication, and construction guidelines when not in conflict with the above listed standards.

The codes and industry standards used for design, fabrication, and construction will be the codes and industry standards, including all addenda, in effect as stated in equipment and construction purchase or contract documents.

3.0 ELECTRICAL DESIGN CRITERIA

3.1 525 kV MOTOR OPERATED DISCONNECTS

The proposed San Gabriel Generating Station (SGGS) will be connected via two overhead lines to Southern California Edison's (SCE) Rancho Vista 525Kv Substation (GIS), which is currently in planning.

To provide a safe and reliable method of delivering power to the Southern California Edison high voltage transmission system, coordination is required between the SGGS and Southern California Edison in order to provide the required tripping of protective devices in the event of malfunction. In addition, total revenue metering and communication between SCE and The San Gabriel Generating Station shall be provided.

The minimum requirements for this interface are defined in Southern California Edison's Interconnection Handbook, Wholesale Generators dated August 17, 2005. This publication specifies protective relay requirements for the generator and interconnecting line to the SCE Switchyard, the required generator accessories and operating conditions, the records and data which must be collected, calibration requirements for protective relays, revenue metering and telemetering requirements and the grounding method between the plant and switchyard. The following is a list of the criteria and technical standards that form the basis for interface requirements on this project.

NERC/WECC Planning Standards

WECC Operating Committee Handbook

WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Plan

CAISO Large Generator Interconnection Procedures, in response to FERC Order No. 2003

IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems

IEEE 80 Guide for Safety in AC Substation Grounding

IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

UL 1741 Inverters, Converters, and Controllers for Use in Independent Power Systems

ANSI C84.1 Voltage Ratings for Electric Power Systems and Equipment

SCE Transmission Planning Criteria and Guidelines

In order to protect both the The San Gabriel Generating Station and the Southern California Edison System from unsafe operating conditions, a dual redundant fiber optic interface will be provided for the tripping and interlock functions. The fiber optic circuits will be embedded in the transmission interconnection shield wires.

All 525-kV switchyard hardware will be hot dip galvanized. The 525-kV disconnect switches will be three-phase, motor operated closed. The entire 525 kV area shall be fenced and lockable gate(s) provided, as required.

The 525 kV transmission line protection, as a minimum, will use a type SEL 321, or equal, distance relay, a line differential relay and other protective relays as required by SCE.

3.2 ELECTRIC MOTORS

3.2.1 General Motor Design Criteria

These paragraphs outline basic motor design guide parameters for selection and purchase of electric motors.

The following design parameters shall be considered:

- Motor manufacturer
- Environment, including special enclosure requirements
- Voltage, frequency, and phases
- Running and starting requirements and, limitations and duty cycle
- Motor type (synchronous, induction, dc, etc.) and construction
- Power factor
- Service factor
- Speed and direction of rotation
- Insulation
- Bearing construction, rating life of rolling elements, and external lube oil system for sleeve or plate bearings
- Ambient noise level and noise level for motor and driven equipment
- Termination provisions for power, grounding, and accessories
- Installation, testing, and maintenance requirements
- Special features (shaft grounding, temperature and vibration monitoring, etc.)
- Motor space heater requirements

3.2.1.1 Safety Considerations for Motors

The California Occupational Safety and Health Act will be adhered to for personnel protection. Belt guards shall be specified for personnel safety and, when required, to prevent foreign objects from contacting belt surfaces. Guard screens will be provided over motor enclosure openings that would otherwise allow direct access to rotating parts. All electrical motors will be adequately grounded.

Motors located in hazardous areas will conform to all applicable regulatory requirements and will be UL labeled. Motor electrical connections are to be terminated within conduit boxes, mounted to the motor frame.

3.2.1.2 Codes and Standards

All motors will be designed, manufactured, and tested in accordance with the latest applicable standards, codes, and technical definitions of ANSI, IEEE, NEMA, and AFBMA, and where supplemented by requirements of the project specifications.

3.2.1.3 Testing Requirements

Each type of alternating current and direct current machine will be tested at the supplier's factory to determine that it is free from electrical or mechanical defects and to provide assurance that it meets specified requirements. The following criteria and tests will be used in testing each type of machine:

1. Fractional horsepower, single-phase induction motors. Test procedures will be in accordance with IEEE 114, Test Procedure for Single-Phase Induction Motors.

2. Integral horsepower, three-phase, 460 volt induction motors.

    a) Routine tests listed in NEMA MG1-12.51, Routine Tests for Polyphase Integral Horsepower Induction Motors.

    b) Test procedures will be in accordance with IEEE 112, Test Procedure for Polyphase Induction Motors and Generators.

3. Induction motors rated above 600 volts.

    a) Routine tests listed in NEMA MG1-20.46, Polyphase Induction Motors for Power Generating Stations, will be performed on each motor.

    b) The following additional tests and inspections will be performed on each motor larger than 500 horsepower.

        - Locked-rotor current at fractional voltage

        - Current balance

        - Final value of motor noise levels including statement that there is no objectionable single frequency noise

4. Direct current motors

    a) The standard routine tests and inspections will be performed on each motor. These shall include the following:

        - High potential dielectric test

        - Measurement of resistance of all windings

        - Inspection of bearings and bearing lubrication system

        - No-load running armature current, shunt field current, and speed in revolutions per minute, at rated voltage.

        - Full load armature current, shunt field current, and speed in revolutions per minute, at rated voltage

    b) Test procedures will be in accordance with IEEE 113, Test Code for Direct Current Machines.

3.2.2 Motors

All motors shall be designed for direct across the line starting and shall not exceed a class B insulation system temperature rise as defined by ANSI C50.41. All motors 25 hp and above shall be provided with motor spaceheaters. Motors shall be of the highest efficiency available for the specified application. Motors shall be NEMA MG 1 compliant unless otherwise stated. All stator windings shall be copper.

3.2.2.1 4000V Motors

Type	Horizontal, single-speed, squirrel-cage, induction.
Voltage rating, phase, frequency	4000 volt, three phase, 60 Hz.
Horsepower rating	1.0 Service factor motors, not less than 115% of the brake horsepower required by the driven equipment when operating at design conditions, and not less than 100% of the brake horsepower required to operate the driven equipment at its maximum requirements.
Nameplate	Shall state the service factor and comply with ANSI C50.41.
Enclosure	WPII
Class of insulation	Class ”F” vacuum pressure impregnated. Insulation system shall be sealed in accordance with NEMA MG-1-20.49.
Temperature rise of windings (maximum by resistance)	In conformance with ANSI C50.41 standards for Class B insulation.
Bearings	Horizontal motors - split sleeve bearings of the oil ring type. A sample drain line shall be provided for obtaining bearing oil samples.
	Vertical motors - sleeve guide
Ambient temperature range	-18°C to 40°C (0 to 104°F)

Limitations on starts	In accordance with ANSI C50.41, a nameplate shall designate the maximum permissible number of starts and the required cooling period when motor is started under conditions of (a) cold rotor and (b) warm rotor (after running continuously at full load for a period of one hour).
Locked rotor (starting) torque at rated voltage and frequency	Not less than 80% of full-load torque.
Pullup and breakdown torques	The torque of the motor shall be 15% above the load torque requirement throughout the entire speed range at 85% of motor-rated voltage with 80% pullup torque as a minimum.
Locked rotor current	Not to exceed 650% of full load.
Base	Soleplates are required.
Sight glasses	Sight glasses shall be furnished in place of oil cups on all oil-filled bearings.
Preparation of storage	Motors shall be prepared for extended outdoor storage by protecting the motor bearings with either a protective grease covering or liquid preservative. The motors shall be tagged to show that a preservative has been used. The procedure to be followed before motors are placed in operation shall also be indicated on that tag.
Heaters	Heaters which total more than 1200 watts in capacity shall be rated for 480 volt AC three-phase and heaters totaling less than 1200 watts in capacity shall be rated for 120 volt ac, single phase. They shall be derated for extended life and shall be sized to prevent condensation at -30°F ambient.
Grounding	Two copper ground pads shall be provided, one on each side of the motor with drilled and tapped holes suitable for attaching two-hole NEMA grounding lugs.

Direction of rotation	Motors shall have the direction of rotation marked on a nameplate for the supply voltage sequence of T_1 - T_2 - T_3.
Magnetic center	The magnetic center at rated load shall be marked on all motors.
Motor test	Motor test shall be performed with motor terminal housing installed on motor.
Air filters	Removable dry type complete with stainless steel filter screens.
Lifting lugs	Suitable lifting lugs shall be provided for hoisting motors during installation and for maintenance purposes.
Sound levels	Warranted maximum A-weighted sound level shall not exceed 85 dBA re: 0.0002 microbar at any point one meter from motor when tested as per IEEE Standard 85.
Instrumentation	Motor winding temperature(s) shall be provide using 100 OHM platinum RTD(S). External junction box shall be provided for easy termination of these motor winding temperature(s) which will be connected to the Facility control system for monitoring.
	Motors with sleeve and plate type thrust bearings shall have Type K bearing thermocouple. External junction box shall be provided as per above

3.2.2.2 Low-Voltage Motors

Type	Horizontal or vertical as required, single-speed, squirrel-cage induction, energy efficient, mill and chemical dry type. Cast iron frames and copper windings only.
Voltage rating, phase, frequency	460 volts, three-phase, 60 Hz, for all motors rated at ½ hp through 400 hp, 115 volts, single-phase, 60 Hz, for all motors below ½ hp.

Horsepower rating	The nameplate horsepower rating shall be equal to, or greater than, the requirements of the driven equipment when operating at design conditions and motor shall be able to handle the maximum capability of the driven equipment within their service factor rating. This relation shall be provided for all operating speeds and conditions.
Service factor	1.15.
Ambient temperature range	-18°C to 40°C (0 to 104°F)
Nameplate	Shall state the service factor and comply with NEMA MG-1.
Enclosure	TEFC totally-enclosed, ventilation, and cooling as applicable to the environment. General purpose and open drip proof enclosure are acceptable for indoor applications only.
Class of insulation	Class F
Temperature rise of windings (maximum by resistance)	In conformance with ANSI C50.41 standards for Class B insulation.

3.3 CABLE AND RACEWAY SYSTEM

3.3.1 Cable

3.3.1.1 5000 Volt Cable

– Conductors	Copper, Class B stranded, annealed
– Insulation material	Ethylene-propylene-rubber (EPR), 133% insulation level
– Jacket for single or multiconductor cables	Per NEC and UL listed as type MV-90 suitable for use in cable tray
– Conductor shield	Extruded semi-conducting thermosetting compound

– Insulation shield	Extruded conducting thermosetting compound
– Metallic insulation shield	Nonmagnetic copper tape
– Voltage	5000 volt

3.3.1.2 600 Volt Power Cable

– Conductors	Copper, Class B stranded, annealed, with a tin or lead-alloy coating, minimum No. 12 AWG
– Insulation material	Ethylene-propylene-rubber (EPR), 90°C
– Jacket for single conductor or multiplexed cables	Per NEC and UL listed as type TC
– Voltage	600 volt

3.3.1.3 600 Volt Control Cable

– Conductors	Copper, Class B stranded, annealed, with a tin or lead-alloy coating, No. 14 AWG
– Insulation material	Ethylene-propylene-rubber (EPR) or cross linked polyethylene (XLPE), or 90^{o}C
– Jacket for single conductor or multiplexed cables	Per NEC and UL listed as Type TC (No PVC)
– Jacket overall	Per NEC and UL listed as type TC
– Voltage	600 volt
– Wire colors for multiconductor cables	NEMA Standard

3.3.1.4 Instrument Cable

– Conductors	Copper, stranded 18 AWG, minimum
– Insulation material	≤90^{o}C, fire retardant XLPE

	>90°C, TFW Teflon tape and Kapton tape over the Teflon
– Jacket over each pair or triad	Per NEC and UL listed as Type PLTC (No PVC)
– Shield	Each pair individually shielded, overall shield is 1.5 mil aluminum or copper-mylar laminate tape
– Drain wire	One per pair
– Voltage	300 volts

3.3.1.5 Thermocouple Cable

– Conductors	ANSI Type E, chromel-constant, or ANSI Type K, chromel-alumel an 16 or 18 AWG
– Insulation material	<90°C, fire retardant XLPE
	>90°C, TFW Teflon tape and Kapton tape over the Teflon
– Jacket overall	Per NEC and UL listed as Type PLTC (No PVC)
– Shield	Each pair individually shielded, overall shield is aluminum or copper-mylar laminate tape
– Voltage	300 volts

3.3.1.6 Testing Requirements

Pre-operational tests will be performed on insulated conductors after installation.

1. Insulated conductors with insulation rated 5,000 volts and above will be given a field dc insulation test after installation as specified in Part 6 of ICEA Standards S-68-516 and S-66-524.

2. Low voltage cables will be either insulation resistance tested prior to connecting cables to equipment or functionally tested (at equipment operation voltage) as part of the checkouts of the equipment system.

3.3.1.7 Miscellaneous

All of the above cable shall conform to, and equipment tests shall be conducted in accordance with, the latest applicable standards of American National Standards Institute (ANSI), Underwriters' Laboratories (UL), the Insulated Cable Engineers Association (ICEA), the Institute of Electrical and Electronics

Engineers (IEEE), and the National Electrical Manufacturer's Association (NEMA), unless otherwise stated herein.

All cables shall meet or exceed flame test requirements of UL 83.

All cable shall be “sunlight resistant” and for use in cable trays (“for CT use”).

Cable with PVC insulation is not allowed in the control room or other normally occupied areas.

Instrumentation and thermocouple cable shall be twisted-shielded with a minimum twist frequency of 3 inches, or 4 twists per foot.

Potential transformer and current transformer leads shall be No. 10 AWG minimum.

All control and instrument leads for the external connections shall be brought out to terminal blocks mounted in terminal boxes, control boards, or panel in an accessible location, including all spare contacts.

Cable shall be identified with identification markers at both ends after cables have been permanently routed, positioned and connected.

Contractor shall adhere to the cable manufacturer's recommendations on minimum pulling temperatures and maximum pulling tension. All cable ends shall be sealed from contamination during the pulling operation, and during storage on cable reels.

Splicing of cables in raceway is not an accepted practice and shall not be allowed without prior approval. Contractor shall receive approval from Owner for any cable that needs to be spliced before the cable is pulled.

3.3.2 Cable Tray

A four-tray cable segregation system shall be furnished: Medium-voltage power, low-voltage power, control, and instrumentation.

The cable tray system shall be designed, fabricated, and installed in accordance with the latest edition of NEMA Standard Publication No. VE-1 - Cable Tray Systems, load/span class designation NEMA Class 12C. The maximum cable fill on cable trays shall be 40% per the National Electrical Code. All cable trays on WRRC property, including the trays routed to the interface point, shall be aluminum.

Flat cable tray covers shall be furnished and installed by the Contractor on all instrument trays, and on power and control trays indoors where the tray passes under grating or open areas where falling debris may damage the cable. Covers on power trays shall be raised covers, if the covered section is over 6 feet long.

Cable trays shall be identified prior to the installation of any cables. Cable trays shall be identified in a distinct, permanent manner with identification numbers at reasonable intervals.

Junction and pull boxes shall conform to UL Standard UL 50. Galvanized coatings for steel boxes shall conform to ASTM A 525 designation G90 for dry locations and G210 for wet and outdoor locations.

All conduits will be sized in accordance with the number and total area of cables that they contain using the National Electric Code.

Conduits with wall thickness suitable for use in concrete encased duct banks will be used and supported by pre-fabricated spacers. PVC conduit may be used for underground duct runs.

Sunlight resistant PVC conduit (Schedule 80) may be used for all conduit work on the ACC except for instrumentation conduit.

All instrumentation and communication cables installed in underground duct shall be routed in iron conduits.

Concrete encased duct banks will be reinforced under roadways and other areas to withstand heavy equipment forces over the duct during construction and operations.

All duct banks have a minimum slope of 0.25 percent and are arranged to drain toward manholes.

Manholes and Handholes: Manholes and handholes will be placed at distances that facilitate cable pulling without exceeding permissible tensions and/or side wall pressures.

Conduits and duct banks will be installed as required to complete the raceway system. Duct banks will use bends with large radius sweeps to minimize pulling tensions. Adequate spare conduits will be installed in duct banks for future use.

3.3.3 General Wiring Requirements

Terminal blocks shall be rated 600 volt, 20 amps. A permanent marking strip, identified in accordance with Contractor's wiring diagrams, shall be furnished on each terminal block. At least 20% (two per 12-point terminal block) spare terminal points shall be furnished.

All control wiring internal to panels shall be 600V, Type SIS, No. 14 AWG minimum, copper conductors with Class D stranding.

All power wiring internal to panels shall be 600V, No. 12 AWG minimum. Power cable #8 AWG and larger shall have copper conductors, with 90°C, heat, moisture, and flame-resistant ethylene-propylene-rubber (EPR) insulation and Hypalon jacket. The EPR insulation shall meet the physical and electrical requirements for Type I insulation as designated in ICEA S-68-516, Sections 3.6.1 and 3.6.2. Power cable internal to panels which is #10 AWG or #12 AWG shall be Type SIS with copper conductors and Class D stranding.

All wiring internal to panels shall be capable of passing the flame test requirements of UL 44, Section 56.

Wiring shall be terminated using compression-type, ring-tongue terminals which firmly grip the conductor. Connectors shall be Thomas & Betts Sta-Kon on Purchaser approved equal. Both ends and at each terminating point of each wire shall be uniquely identified with permanent, heat shrinkable wire markers (125°C rated) (Raychem Thermofit) or other Owner-approved permanent marker using indelible printing, white sleeve with black lettering.

Splicing of wiring is prohibited. No more than one wire plus one jumper shall be connected to any one terminal point.

All 480V wiring shall be segregated from other control wiring and low voltage devices for personnel safety by means of an insulated barrier or other means.

Only one ground connection shall be provided for each instrument circuit. Ground connection for shield wiring shall be of the power source.

All switchgear assemblies shall be furnished completely wired. With the exception of control and AC power buses, all other alarm and control wiring for extension to remote equipment or for interconnection between compartments shall terminate at terminal blocks.

Wiring shall be neatly arranged and clamped securely to panels to prevent movement or breaking. Except as otherwise proved in standard vendor supplied packages, a maximum of 12 wires shall be in a bundle in order to facilitate tracing of wires. Wiring clamps and supports at hinge transition points shall be properly sized to prevent chafing of insulation when the cubicle door is opened and closed. Metal clamps must have insulating inserts between the clamps and wiring. Nonmetallic clamps are preferred.

All signal level cables installed in underground duct shall be in iron conduits. There shall be an independent raceway system for the telephone/communications system.

3.4 PROTECTIVE RELAYING

The selection and application of protective relays are discussed in the following paragraphs. These relays protect equipment in the Auxiliary Power Supply System, Generator Terminal Systems, 230-kV System, Turbine-Generator System, and the electrical loads powered from these systems.

3.4.1 Generator Protective Relays

The following generator protective relays and protection schemes shall be provided:

a. Phase fault protection, generator differential
b. Ground fault protection during normal operation and for ground faults close to the neutral
c. Short reach loss of field with time delay and long reach loss of field
d. Negative sequence
e. Dual volts per Hertz with stepped activation
f. Voltage balance
g. Generator motoring protection
h. Synchronism check
i. Exciter and generator field ground fault protection
j. Over excitation protection
k. Transfer trip from switchyard or substation
l. Stator over temperature protection
m. Under voltage protection
n. Generator breaker failure protection
o. Lockout relay for generator breaker trip

3.4.2 Generator Bus and Transformer Protective Relaying

Protection for the generator bus and main power transformers shall be provided by the same relaying systems used to protect the generator against phase faults and ground faults.

a. Differential (87B)
b. Neutral overvoltage (59N)

3.4.3 Main Power Transformer Protective Relaying

The following main power transformer relays and protection schemes shall be provided:

a. Main power transformer, generator breaker, and generator bus zone differential relaying
b. Fault pressure relaying
c. Mechanical fault pressure relief device
d. Lockout relay for main power transformer, generator bus, and unit auxiliary transformer trip
e. Transformer differential relays, primary

3.4.4 Auxiliary System Relaying

The auxiliary system shall be protected by relaying as listed below:

a. Unit auxiliary transformers shall be protected by a single differential relay
b. Unit auxiliary transformers shall be medium-resistance grounded with a ground detection relay to trip
c. Unit auxiliary transformers shall have instantaneous and over current protection, as well as differential protection.
d. Medium-voltage bus supply and tie breakers shall have over current relays, one per phase
e. Medium-voltage loads shall have zero sequence ground detection
f. Medium-voltage loads shall have instantaneous and over current protection, one per phase
g. Bus transfer synchro-check relaying as described in Section 2.3.1.3.2

3.4.5 Major Interlocks

The major generator and transformer electrical equipment interlocks are:

a. The generator breaker cannot be closed unless the excitation system breaker is closed.
b. The excitation system breaker cannot be tripped by control switch unless the generator breaker is open.
c. When the main power transformer 525 kV breakers are open, breakers (verify 2 breakers with SCE) cannot be closed unless its respective generator breaker is open.
d. When only one main power transformer breaker is closed it cannot be opened until its respective generator breaker is opened.

3.4.6 Lockout Relay Actions

One lockout relay shall be associated with generator protection only, and all trips requiring the opening of the generator breaker and removing excitation shall operate this lockout relay. The operation of this relay will not cause the trip of the combustion turbine, which will continue to fire to provide heat and airflow for the HRSG (combined cycle option).

A second lockout relay will be provided for the generator to clear the associated 230 kV substation breakers and will transfer trip the generator protection lockout relay.

All lockout relays provided must be monitored and alarmed on coil failure, with the monitoring being handled in such a manner that the reliability of the circuit is not compromised. Indicating lights shall be used to monitor the integrity of the lockout relay power. An alarm shall be provided to alert on loss of power. As an alternate to alarming, two lockout relays for each function may be provided. All lockout relays and indicating lights, including those provided for generator protection, shall be located in the main control room on the protective relay panel.

3.5 CLASSIFICATION OF HAZARDOUS AREAS

Areas where flammable and combustible liquids, gases, and dusts are handled and stored will be classified for the purpose of determining the minimum criteria for design and installation of electrical equipment to minimize the possibility of ignition. The criteria for determining the appropriate classification are specified in Article 500 of the National Electrical Code (NFPA/ANSI C1).

In addition to defining hazardous areas by class and division, each hazardous element is also assigned a group classification (A, B, C, etc.). The group classifications of hazardous elements are specified in Article 500 of the NEC.

Electrical equipment in areas classified as hazardous will be constructed and installed in accordance with the requirements of Articles 501and 502 of the National Electrical Code.

References for use in classification of areas, as well as specification of requirements for electrical installation in such areas, include the following:

- National Electrical Safety Code ANSI C2
- National Electrical Code ANSI C1, NFPA 70/ANSI C1
- National Fire Codes, National Fire Protection Association codes, standards, and recommendations
- American Petroleum Institute Recommended Practices

3.6 GROUNDING

The station grounding system will an interconnected network of bare copper, conductor and copper clad ground rods. The system will be provided to protect plant personnel and equipment from the hazards which can occur during power system faults and lightning strikes.

3.6.1 Design Basis

The station grounding grid will be designed for adequate capacity to dissipate heat from ground current under the most severe conditions in areas of high ground fault current concentrations, with grid spacing such that safe voltage gradients are maintained. Bare conductors to be installed below grade will be spaced in a grid pattern to be indicated on the construction drawings. Each junction of the grid will be bonded together by a compression connectors or an exothermal welding process.

Grounding stingers will be brought through the ground floor and connected to the building steel and selected equipment. The grounding system will be extended, by way of stingers and conductor installed in cable tray, to the remaining plant equipment. Equipment grounds will conform to the following general guidelines:

1. Grounds will conform to the NEC and NESC.
2. Major items of equipment, such as switchgear, secondary unit substations, motor control centers, relay panels, and control panels, will have integral ground buses which will be connected to the station ground grid.
3. Electronic panels and equipment, where required, will be grounded utilizing an insulated ground wire connected in accordance with the manufacturer's recommendations.
4. The grounding system for this unit will be connected to the existing plant grounding system.

3.6.2 Materials

Grounding materials furnished are described below:

1. Rods will be copper. Ground rod length and diameter will be determined by soil resistivity and subsurface mechanical properties.
2. Cable will be soft-drawn copper with Class B stranding or copper-clad steel.
3. Exothermal welds, where required, will use molds, cartridges, and materials as manufactured by Cadweld or equivalent.
4. Clamps, connectors, and other hardware used with the grounding system will be made of copper.

3.7 SITE LIGHTING

The site lighting system will provide personnel with illumination for the performance of general yard tasks, safety, and plant security. Typical lighting would be downward-directed lighting to minimize glare and light pollution.

3.7.1 Light Sources

The lighting system will be designed in accordance with the Illuminating Engineering Society (IES) to provide illumination levels recommended by the following standards and organizations:

1. ANSI/IES RP-7, 1979, Industrial Lighting
2. ANSI/lES RP-8, 1977, Roadway Lighting

3. Occupational Safety and Health Act (OSHA)

Light source size and fixture selections will be based on the applicability of the luminaries for the area under consideration during detail design.

3.7.2 Roadway and Area

Roadway and area lightning will be designed using high-pressure sodium light sources. The light fixtures will be the cutoff type designed to control and direct light within the property line of the facilities. Roadway light fixtures will be installed on hot-dipped galvanized steel poles. Local task lightning will be installed on structures or equipment.

3.7.3 Lighting Control

Electric power to light fixtures located outdoors will be switches on and off with photoelectric controllers. Local task lightning will be controlled with photoelectric controllers and switches manually at the task.

3.8 FREEZE PROTECTION

A freeze protection system will be provided for selected outdoor piping as required. Parallel circuit type heating cable will be utilized where possible. These heating cable circuits can be assembled and installed in the field using the appropriate connection kits.

Power distribution panelboards will furnish power to the freeze protection circuits.

3.9 LIGHTNING PROTECTION

Lightning protection will be provided as required in NFPA 780.

3.10 CATHODIC PROTECTION SYSTEM

Consideration will be given to the need for cathodic protection and other corrosion control measures for all plant structures, including the following structures:

1. The exterior surface of underground welded carbon steel pipe, copper pipe, stainless steel pipe, cast iron and ductile iron pipe, and prestressed concrete cylinder pipe.

2. The bottoms of surface mounted steel tanks.

It is expected that buried bare copper ground grid components will be in close proximity to, but not in contact with, underground welded steel piping and welded steel tank bottoms.

Measures will be taken for the control of corrosion so as not to materially reduce the total effectiveness of the plant electrical safety grounding systems.

The methods to be used for cathodic protection will be a sacrificial anode system or an impressed current cathodic protection system, or both. The detailed design will be determined after tests to determine minimum average soil resistivity or layer resistivity which may be expected in pipe burial zones.

The cathodic protection system for this unit will be compatible with the system for the existing units.